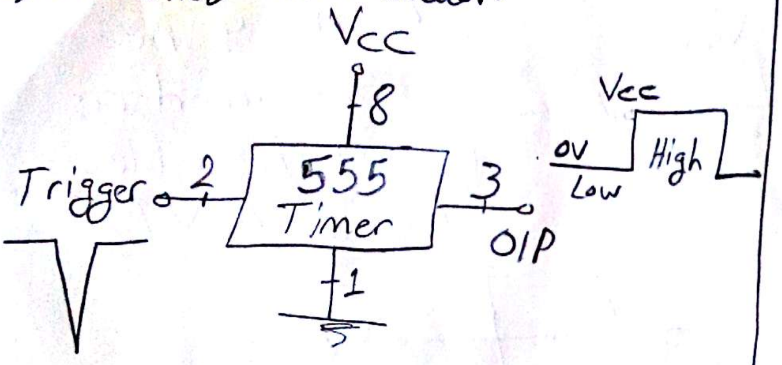
555 Timer IC

* It's an IC than can operate as either monostable or astable multivibrator.

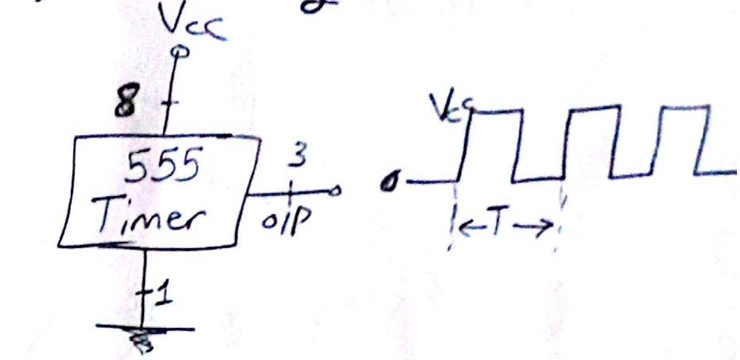
Monostable

⇒ One-Shot multivibrator.

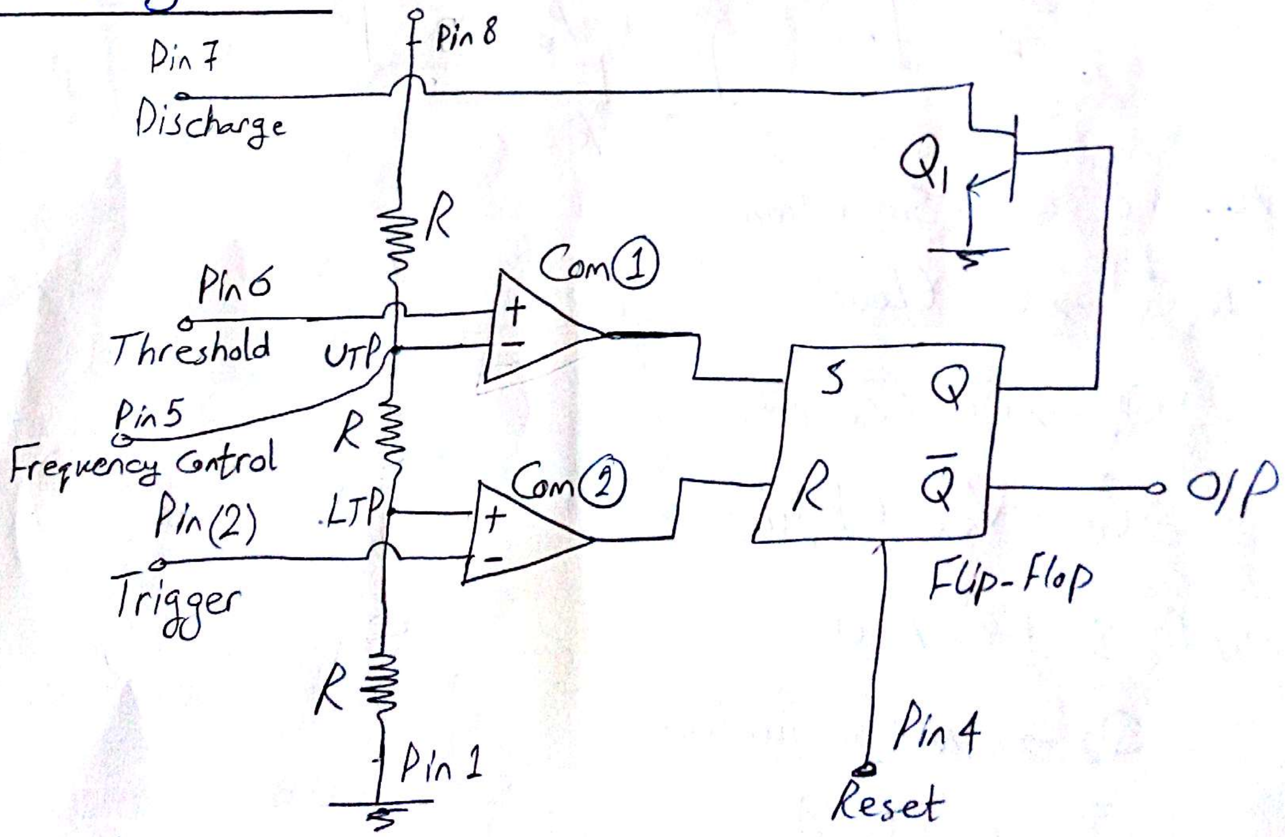


Astable

⇒ Free-running multivibrator.



* Block Diagram:-

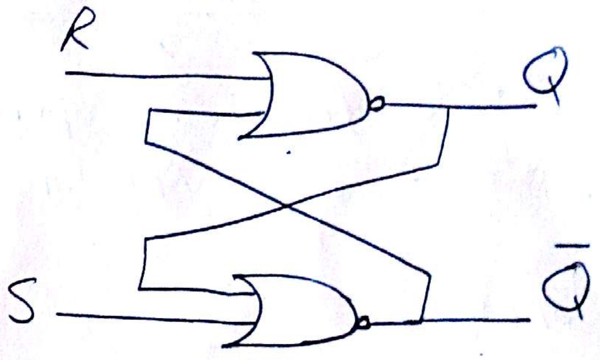


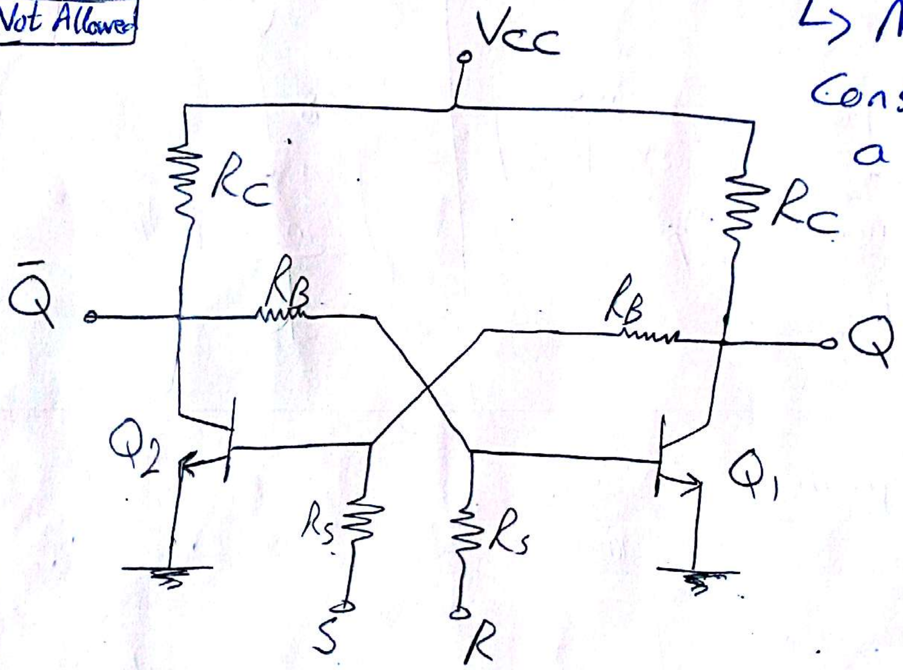
$$V_{UTP} = \frac{2V_{cc}}{3}$$ → Upper Trigger Point

$$V_{LTP} = \frac{V_{cc}}{3}$$ → Lower Trigger Point

* RS Flip-Flop :-

S	R	Q	$\bar{Q}$
0	0	No change	
0	1	0	1
1	0	1	0
1	1	Not Allowed	





↳ May be considered as a bistable MVT.

① Assume $Q_1 \rightarrow$ Saturation

$\therefore Q \rightarrow 0$ (Low)

$\therefore Q_2 \rightarrow$ off (cutoff)

$\therefore \bar{Q} = V_{cc}$ (High)

$\Rightarrow$ If $S=1$, $R=0$

$\therefore Q_2 \rightarrow$ ON (saturation)

$\therefore \bar{Q} \simeq 0$ (Low)

$\therefore Q_1 \rightarrow$ off

$Q \simeq V_{cc}$ (High)

If: $S=0, R=1$

$Q_1 \rightarrow$ ON (Saturation)

$\therefore Q \simeq 0$ (Low)

$\therefore Q_2 \Rightarrow$ off (cutoff)

$\therefore \bar{Q} \simeq V_{cc}$ (High)

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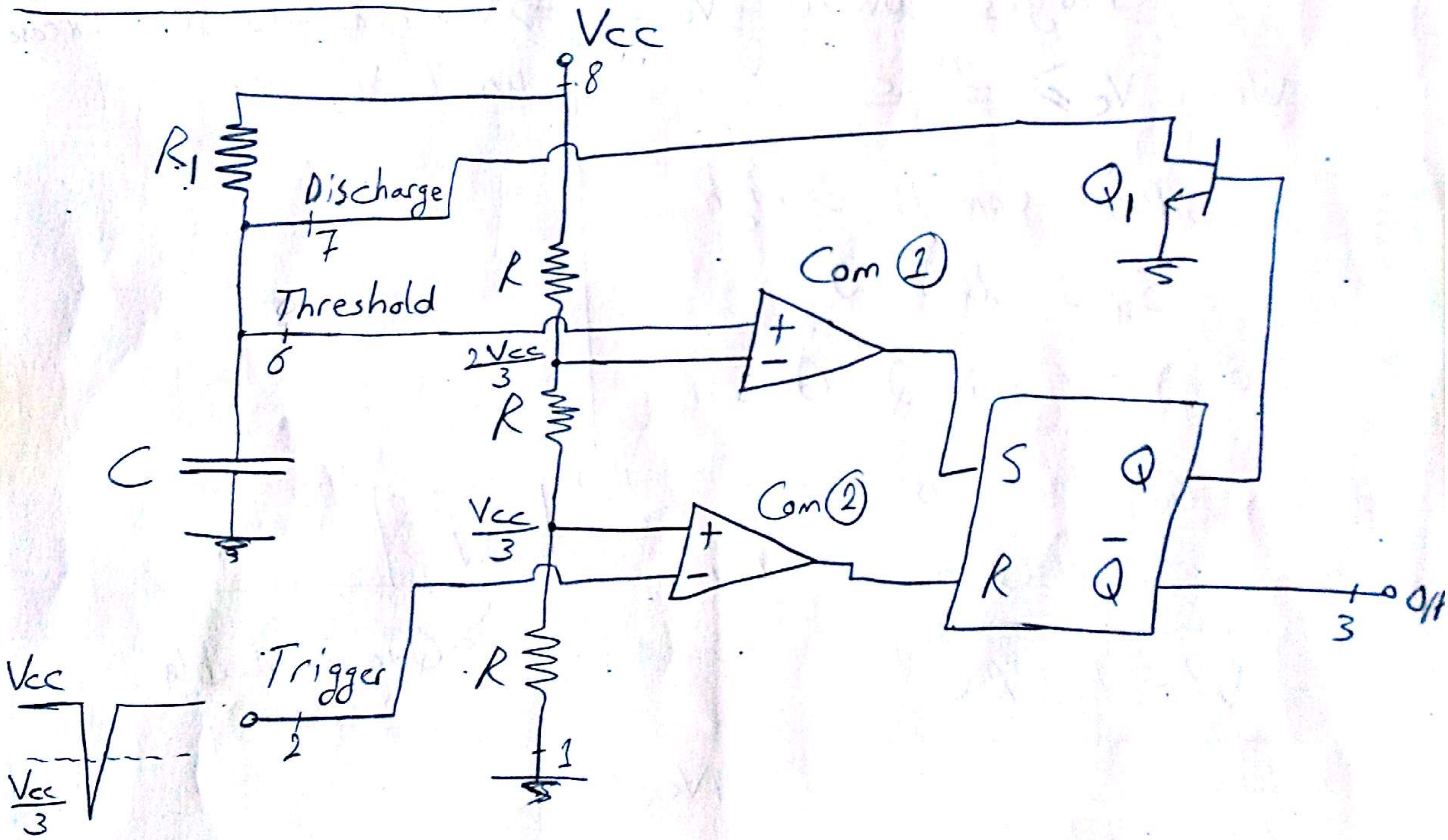
* Monostable 555 :-



$\Rightarrow$ Assume $Q = $ Logic 1 & $\bar{Q} = $ Logic 0 :

$\therefore Q_1 \rightarrow$ Saturation

$\therefore V_C = 0$

$\Rightarrow$ When Trigger is Applied:

If $V_{Trigg} > \frac{Vcc}{3}$ $\Rightarrow$ Comparator ② O/P is Low

O/P of Com ① is low

If $V_{Trigg.} < \frac{V_{cc}}{3}$

∴ O/P of Comparator 2 is High

∴ R = Logic high

∴ $R = 1$ & $S = 0$

∴ $Q = 0$, $\bar{Q} = 1$

∴ $Q_1 \rightarrow$ Cutoff

∴ C charges towards V_{cc}

When $V_c \geq \frac{2V_{cc}}{3}$

∴ O/P of Com 1 is high

∴ $S = 1$ & $R = 0$

∴ $Q = 1$ & $\bar{Q} = 0$

∴ $Q_1 \rightarrow$ Saturation

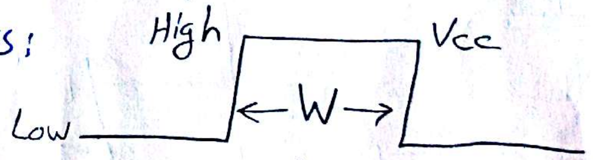
∴ C ~~charges~~ discharges through the BJT path.

∴ O/P of com 1 becomes Low

⇒ V_c continues to decrease until $V_c = 0$.

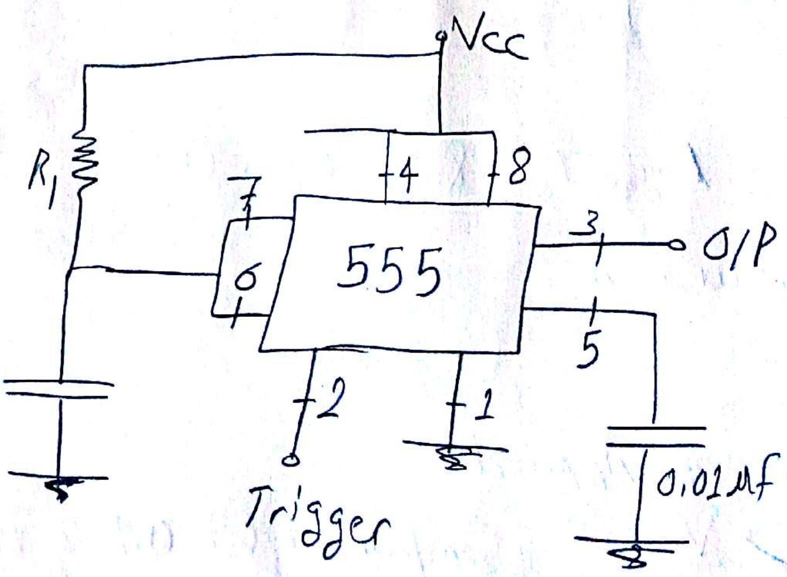
⇒ The output is as follows:

↳ $\bar{Q}$



↳ Quasi-Stable State.

$$\boxed{W = 1.1\,RC}$$



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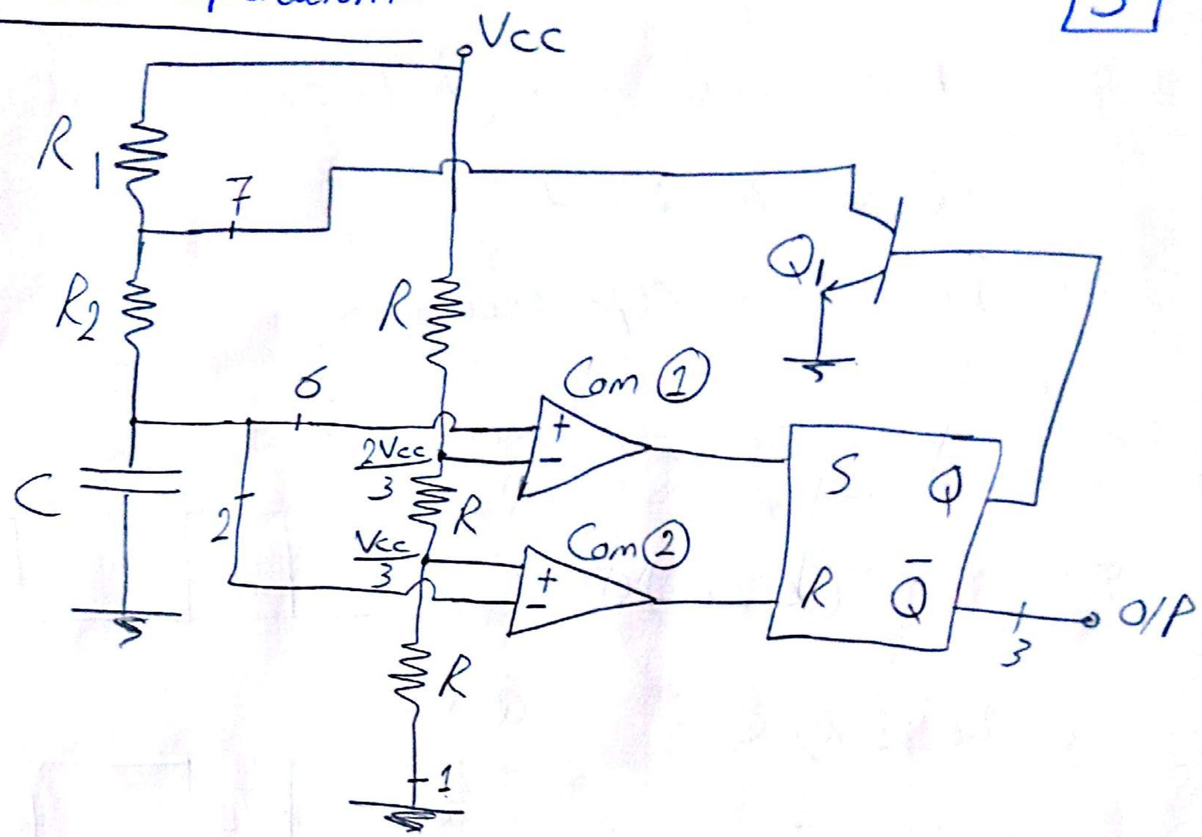
* Astable 555 Operation:-



⇒ Assume $Q = 0$ & $\bar{Q} = 1$

∴ $Q_1 \rightarrow$ Off

∴ C charges through (R_1 & R_2) towards Vcc

$V_c > \frac{Vcc}{3}$ ⇒ O/P of Com ② is Low ($R = 0$)

When $V_c > \frac{2Vcc}{3}$

∴ O/P of Com ① is high ($S = 1$)

∴ $S = 1$ & $R = 0$

∴ $Q = 1$ & $\bar{Q} = 0$

∴ $Q_1 \Rightarrow$ ON

∴ C discharges through R_2

∴ O/P of Com ① is Low ($S = 0$) → No change

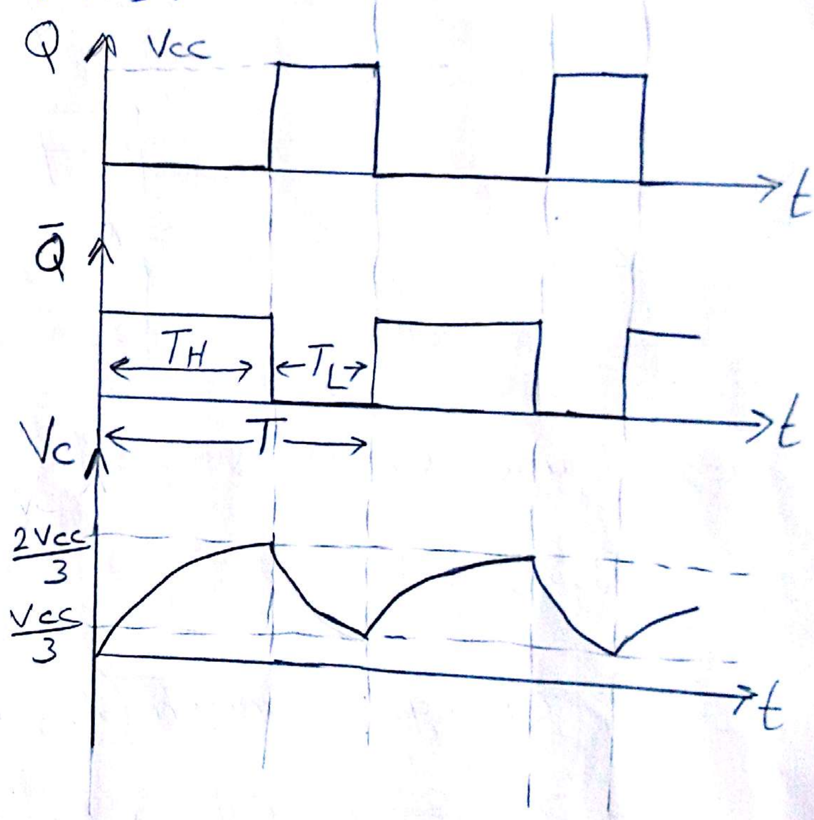
⇒ When $V_c < \frac{V_{cc}}{3}$

∴ O/P of Com ② is high ($R=1$)

∴ $Q = 0$ & $\bar{Q} = 1$

The process is repeated.

⇒ The O/P & V_c waveforms:



$T_H = 0{,}693 (R_1 + R_2) C$

$T_L = 0{,}693 \, R_2 C$

$\Rightarrow T = T_H + T_L$

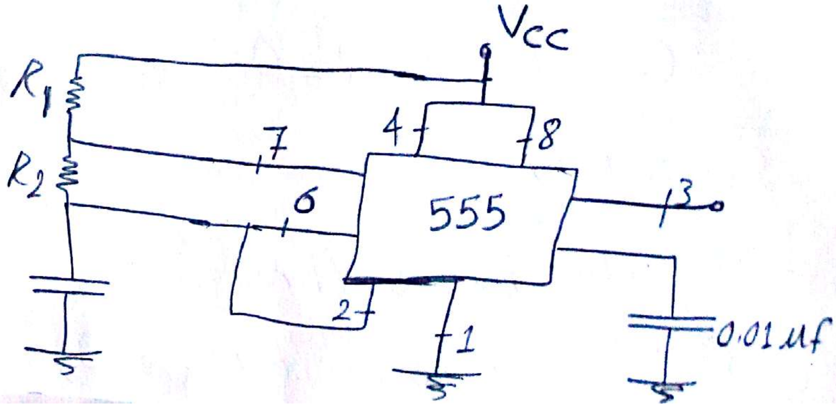
$= 0{,}693 (R_1 + 2R_2) C$

$\Rightarrow f = \frac{1}{T} = \frac{1{,}44}{(R_1 + 2R_2) C}$

⇒ Duty Cycle: $D = \frac{T_H}{T_H + T_L} = \frac{R_1 + R_2}{R_1 + 2R_2}$

⇒ For 50% duty cycle: Choose R_1 ~~very~~ to be very small

$D \simeq \frac{R_2}{2R_2} = \frac{1}{2}$



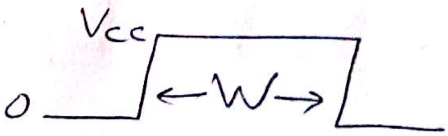
555 Problems

(1) For the monostable 555 circuit previously explained; if $C = 0.5nf$

Find the Value of R so that the output pulse has a width of $10\,\mu s$.

Solution

$W = 1.1\,RC$



$\therefore 10 * 10^{-6} = 1.1 * 0.5 * 10^{-9} * R$

$\therefore R = 18.18\,k\Omega$

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(2) For the Astable circuit:

$C = 680\,pf$

O/P is square wave with $f = 20kHz$

$D = 80\%$

Find R_1 & R_2

Solution

$$D = \frac{R_1 + R_2}{R_1 + 2R_2}$$

$$\therefore 0.8 = \frac{R_1 + R_2}{R_1 + 2R_2}$$

$\frac{4}{5}$

$\therefore 5(R_1 + R_2) = 4(R_1 + 2R_2) \Rightarrow \therefore R_1 = 3R_2 \rightarrow (1)$

$F = 20\,kHz$

$\therefore T = \dfrac{1}{20 * 10^3} = 50\,\mu s$

$\because T = 0.693\,C(R_1 + 2R_2)$

$50\,\mu s$

$\therefore 50 * 10^{-6} = 0.693 * 680 * 10^{-12}(3R_2 + 2R_2)$

$\therefore R_2 = 21.31\,k\Omega$

$\therefore R_1 = 63.93\,k\Omega$

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